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Chemical composition of three herbaceous tropical forage legumes grown successfully in Zimbabwe

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***Desmodium uncinatum*, *Stylosanthes guianensis* and *Macroptilium atropurpureum*, grown at the University of Zimbabwe Farm, were harvested serially in the early (December), mid (February) and late (April) growing season in 1992/93 and oven-dried. Field-cured hays were also made from the legumes in April 1993 and 1994. The legumes differed in phenological development which, in turn, influenced crude protein (CP) levels. The CP content of *S. guianensis* (132 to 167 g/kg dry matter) was the least and first rose and then fell, that of *D. uncinatum* (195 to 234 g/kg DM) decreased, while that of *M. atropurpureum* (189 to 229 g/kg DM) increased with the season. Neutral detergent fibre (NDF) was higher in the early (364 to 440 g/kg DM) than in the mid to late season (470 to 559 g/kg DM). *S. guianensis* was the most fibrous in April, while *D. uncinatum* contained the most lignin across the season (148 to 159 g/kg DM). The legumes, especially *M. atropurpureum*, were rich in calcium (9.8 to 20.4 g/kg DM) and phosphorus (1.8 to 3.3 g/kg DM). Hay making was associated with loss of quality (e.g., 14 to 31 percent less CP and 12 to 51 percent more NDF) that was attributable to leaf loss. *D. uncinatum* hay contained the most fibre, lignin and acid detergent insoluble nitrogen and the least minerals. It is concluded that, overall, *M. atropurpureum* was chemically the most nutritious legume.**

Keywords: chemical composition, tropical forage legumes, Zimbabwe.

Introduction

Ruminant livestock production in the high rainfall areas of Zimbabwe is based primarily on natural pasture (veld) grasses. However, the grasses are deficient in protein for most of the year (Elliott and Folkertsen, 1961), leading to reduced animal production. Herbaceous tropical forage legumes have a potential to alleviate the protein deficiency at a lower cost than conventional protein concentrates (Barnes and Clatworthy, 1976). Unfortunately, the legumes that occur naturally in the veld are either too sparsely distributed or unpalatable to the grazing animals and, therefore, do not contribute significantly to animal production. Nevertheless, improved herbaceous tropical forage legumes, namely, *Desmodium uncinatum* cv. Silverleaf (Silverleaf *Desmodium*), *Stylosanthes guianensis* var. *intermedia* cv. Oxley (fine-stem stylo) and *Macroptilium atropurpureum* cv. Siratro (Siratro) have been grown successfully in Zimbabwe for use in reinforcement of veld and planted grass pastures and as protein banks. Considerable information is available on the ecological and agronomic attributes of the legumes (Robinson and Clatworthy, 1980).

The beneficial effect of the legumes on animal production from grazed pastures has been demonstrated (Clatworthy and Holland, 1979; Clatworthy, 1984). However, a more satisfactory and complete appraisal of the legumes is needed to quantify and compare the supply of nutrients to animals by the legumes. Chemical composition is the fundamental determinant of the potential of forages to supply nutrients. Not only does it provide information on levels of nutrients but also of certain forage constituents that are statistically associated positively or negatively with feed intake and digestibility (Van Soest, 1982).

Accordingly, as a first step in the nutritive evaluation of Silverleaf *Desmodium*, fine-stem stylo and Siratro grown under Zimbabwean conditions, the objective of this study was to provide information on nutritionally important parameters of chemical composition of the legumes.

Materials and Methods

Forage production

Pure stands of fine-stem stylo and Siratro were established in February 1992 on about 0.5 ha of deep, well drained, red clay soil at the University of Zimbabwe Farm, just north of Harare. The plots received an application of 'Compound V' fertilizer (four percent N, 17 percent P_2O_5, 15 percent K, eight percent S and 0.1 percent B) at the rate of 400 kg per ha and lime at the rate of 2 000 kg per ha. A 0.5 ha plot of an existing two year old pure stand of Silverleaf *Desmodium*, on similar soil and on which a clearing cut was done in May 1992, was selected for use in this study. Soil samples were taken for laboratory analysis from all the legume plots in October 1992 and fertilizers were applied in order to bring soil pH to about 6.5 and phosphate levels to about 20 parts per million (ppm). No fertilizers were applied in subsequent years. The plots were kept clean by hand weeding. During the 1992/93 growing season (November to April), 913 mm of well distributed rainfall was received, while below average rainfall (585 mm) was received in the 1993/94 growing season.

Fifteen quadrats, measuring 0.5 m x 0.5 m, were located at random in each plot at least two metres from the edge of the plot. Each quadrat was further assigned at random to one of three dates of harvesting, namely, the early (4 December 1992), mid (3 February 1993) and late (5 April, 1993) growing season. The legumes were harvested with sickles at a stem length of about five cm from ground level. For each date of harvesting, five quadrat samples from each plot were bulked, thoroughly mixed and placed in metal trays. The forages were dried in a forced draught oven for 48 hours at 62^{0}C, milled through a two mm screen and stored in plastic bags at room temperature. Field-cured hay was made by harvesting whole plots of the legumes with sickles from 5 to 9 April 1993 and, again, from 11 to 15 April 1994. The hay was sun-dried in windrows in the field, milled to about 25 mm lengths and stored in hessian bags under a shed. Though not initially planned, three sub-samples of the 1992/93 serially harvested samples and of the 1994 hays were taken prior to milling and separated into leaves, pods and stems to provide additional information. Flowers were included with the leaves. The sub-samples were milled through a two mm screen and stored in plastic bags at room temperature.

Chemical analysis

After thorough mixing, sub-samples of the milled serially harvested legumes, the field-cured hays and the leaf and stem fractions were taken for further milling through a one mm screen before laboratory analysis. Triplicate samples were then analysed for dry matter (DM), ash, nitrogen, ether extract (EE), calcium (Ca) and phosphorus (P) according to AOAC (1975) and for neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and acid detergent insoluble nitrogen (ADIN) according to the methods of Goering and Van Soest (1970).

Statistical analysis

The General Linear Models Procedure (SAS Institute, 1985) for a completely random design was used to analyse the chemical composition data for the entire plant materials. Sums of squares of data from the serially-harvested samples were partitioned according to date of harvest, legume type, their interaction and residual. Sums of squares of the field-cured hay data were partitioned into legume type and residual. The protected LSD test (Steel and Torrie, 1980) was used to separate means. The leaf and stem fractions data were not subjected to statistical analysis as the measurements were not pre-planned.

Results

Serially-harvested and oven-dried samples

The legumes differed in their phenological development (Table 1). Silverleaf *Desmodium* was vegetative during most of the growing season and was only turning reproductive at the beginning of April. In contrast, fine-stem stylo was reproductive during the entire growing season, with seed-ripening occurring in the latter part of the growing season.

There were differences in crude protein (CP) content of the legumes which varied from one growth stage to another ($P<0.001$) (Table 2). Fine-stem stylo had the lowest CP content throughout the growing season, ranging from 132 g/kg DM in April to 167 g/kg DM in February. In December, Silverleaf *Desmodium* contained more CP than Siratro. Thereafter, there was more CP in Siratro than in Silverleaf *Desmodium*. The CP content of Silverleaf *Desmodium* declined from 234 g/kg DM in December to 195 g/kg DM in April, while that of Siratro increased from 189 g/kg DM in December to more than 220 g/kg DM in February and April.

Table 1: Growth stages of legumes at harvesting.

Month of Harvesting	Legume	Growth stage
December	Silverleaf desmodium	Vegetative
	Fine-stem stylo	Flowering
	Siratro	Flowering, seed setting and seed ripening
February	Silverleaf desmodium	Vegetative
	Fine-stem stylo	Flowering profusely
	Siratro	Mainly vegetative with very few flowers and pods
April	Silverleaf desmodium	Mainly vegetative with some flowers and pods
	Fine-stem stylo	Flowering, seed setting and ripening, many
	Siratro	stems dying back Flowering profusely and
		setting seed with few mature pods

Table 2: Protein and fibre content (g/kg DM) of Silverleaf *Desmodium* (SL), fine-stem stylo (FS) and Siratro (ST) harvested in December, February and April and oven-dried.

		Month (M)				Significance		
	Legume (L)	December	February	April	s.e	L	M	LxM
Crude protein	SL	234	210	195	3.6	***	***	***
	FS	146	167	132				
	ST	189	222	222				
Neutral detergent fibre	SL	364	470	481	10.8	***	***	***
	SF	432	494	559				
	ST	440	473	485				
Acid detergent fibre	SL	356	392	434	11.8	**	***	
	FS	369	422	455				
	ST	333	408	394				
Acid detergent lignin	SL	159	148	148	6.8	***	*	*
	PS	110	130	136				
	ST	101	100	126				

*P< 0.05 **P< 0.01 ***P< 0.001

Differences in NDF (cell wall) content of the legumes were highly dependent on stage of growth ($P<0.001$) (Table 2). In December, the NDF content of Silverleaf *Desmodium* (364 g/kg DM) was lower ($P<0.05$) than that of the other two legumes (average 436 g/kg DM). In February, all the legumes contained more NDF than in December but there were no differences among the legumes (average 479 g/kg DM) ($P>0.05$). In April, fine-stem stylo was more mature and contained more NDF (559 g/kg DM) than the other two legumes (483 g/kg DM). The ADF (ligno-cellulose) content increased progressively with season in all the legumes ($P<0.001$). The ADF was higher in fine-stem stylo than in Siratro in December and was higher in fine-stem stylo and Silverleaf *Desmodium* than in Siratro in April ($P<0.01$). Differences in ADL content of the legumes were dependent on month of harvest ($P<0.05$). In the early season, Silverleaf *Desmodium* contained more ADL (159 g/kg DM) than fine-stem stylo and Siratro (106 g/kg DM). By April, the ADL content of Silverleaf *Desmodium* was higher than that of Siratro only ($P<0.05$).

The legumes did not differ ($P>0.05$) in EE content (mean 49 g/kg DM) throughout the growing season (Table 3). Differences in ash ($P< 0.001$) and Ca ($P<0.01$) levels were dependent on season (Table 3). In December, Siratro contained more ash (less organic matter) and Ca than the other legumes ($P<0.05$). Subsequently, Siratro and fine-stem stylo contained more ash and Ca than Silverleaf *Desmodium* ($P<0.05$). The ash and Ca content of fine-stem stylo tended to first rise and then fall, while those of the other legumes declined progressively with the growing season. Differences in P content were also dependent on season ($P<0.05$) (Table 3). There were no differences in P content early in the growing season ($P>0.05$). In February, Siratro was a richer source of P than fine-stem stylo ($P<0.05$). By April, Siratro was a richer source of P than fine-stem stylo and Silverleaf *Desmodium* ($P<0.05$). While the P content of Silverleaf *Desmodium* and fine-stem stylo declined ($P<0.05$), that of Siratro tended to increase as the season progressed.

The leaf content of the legumes and the levels of CP in leaves and stems are given in Table 4. In December, the content of leaves tended to be highest in Silverleaf *Desmodium*, followed by Siratro and fine-stem stylo, in that order. Subsequently, the order was Siratro, Silverleaf *Desmodium* and fine-stem stylo, respectively. As the season progressed from December to April, the leaf fractions of Silverleaf *Desmodium* and fine-stem stylo declined by 0.29 and 0.06, respectively, while that of Siratro increased by 0.21. A lot of leaf loss was observed in the Silverleaf *Desmodium* plot due to self-shading as the legume became more mature. Protein levels tended to be higher in leaves than in stems. Leaf protein in December tended to be highest in Silverleaf *Desmodium*, followed by Siratro and fine-stem stylo, in that order. Subsequently, the order was Siratro, Silverleaf *Desmodium* and fine-stem stylo, respectively. Leaf CP in Siratro and Silverleaf *Desmodium* was above 220 g/kg DM throughout the season, while that of fine-stem stylo tended to first rise (to just above 220 g/kg DM in February) and then fall with the season. Protein levels in stems tended to be highest in Silverleaf *Desmodium* in December and February, followed by Siratro and fine-stem stylo, in that order. In April, Siratro stems tended to have the highest CP, followed by Silverleaf *Desmodium* and fine-stem stylo, in that order.

Table 3: Ether extract and mineral content (g/kg DM) of Silverleaf *Desmodium* (SL), fine-stem stylo (FS) and Siratro (ST) harvested in December, February and April and oven-dried.

		Month (M)				Significance		
	Legume (L)	December	February	April	s.e	L	M	LxM
Ether extract	SL	48	49	47	4.3			
	FS	53	45					
	ST							
Ash	SL	77	59	47	2.1	***	***	***
	FS	73	83	65				
	ST	102	82	69				
Calcium	SL	16.5	12.4	9.8		***	***	**
	FS	16.7	17.2	13.8				
	ST	20.4	16.3	13.0				
Phosphorus	SL	2.9	2.8	2.0	0.21	***	*	
	FS	2.5	2.2	1.8				
	SL	2.6	3.3	3.0				

*P< 0.05 **P< 0.01 ***P< 0.001

Table 4: Mean leaf content and levels of crude protein in leaves and stems (g/kg DM) of legumes harvested at different times in the growing season and oven-dried (n = 3).

		Month		
	Legume	December	February	April
Leaf content	Silverleaf *Desmodium*	792	583	565
Fine-stem stylo	474	412	444	
	Siratro	522	643	630
Crude protein (leaves)	Silverleaf *Desmodium*	231	226	255
	Fine-stem stylo	184	223	166
	Siratro	223	272	263
Crude protein (stems)	Silverleaf *Desmodium*	177	179	106
	Fine-stem stylo	76	108	80
	Siratro	107	150	147

Field-cured legume hays

Data on the chemical composition of the legumes following harvesting in April and sun curing into hay in the field are given in Table 5. Overall, the field-cured hays were chemically poorer in quality than the serially-harvested and oven-dried samples that were harvested at the same time.

Table 5: Composition of legumes (g/kg DM) harvested in April 1993 and 1994 and field-cured into hay.

	Silverleaf *Desmodium*	Fine-stem stylo	Siratro	s.e.
1993 crop (entire forage):				
Crude protein	143^{b}	114^{a}	159^{c}	2.1
Neutral detergent fibre	728^{c}	625^{a}	652^{b}	6.2
Acid detergent fibre	652^{c}	535^{a}	553^{b}	2.4
Acid detergent lignin	222^{c}	188^{b}	180^{a}	2.4
Acid detergent insoluble nitrogen:				
g/kg DM	14.0^{c}	5.2^{a}	7.0^{b}	0.30
g/kg total N	608^{b}	285^{a}	273^{a}	13.3
Ether extract	5.2^{a}	5.3^{a}	5.4^{a}	0.16
Ash	48^{a}	70^{b}	90^{c}	1.6
Calcium	8.8^{a}	12.0^{c}	10.1^{b}	0.09
Phosphorus	1.2^{a}	1.7^{b}	1.7^{b}	0.04
1994 crop (n = 3):				
Leaf content	454	423	373	
Crude protein (entire forage)	121	81	123	
Crude protein (leaves)	203	116	180	
Crude protein (stems)	80	68	109	

^{a,b,c}Means in a row with different superscripts are different ($P < 0.05$).

In terms of CP content, Siratro was the most nutritious and fine-stem stylo the least nutritious ($P<0.05$) (Table 5). The NDF and ADF levels were highest in Silverleaf *Desmodium* and lowest in fine-stem stylo ($P<0.05$). The ADL content was also highest in Silverleaf *Desmodium* hay but lowest in Siratro hay ($P<0.05$). The level of ADIN was higher in Silverleaf *Desmodium* hay (608 g/kg total nitrogen) than in the fine-stem stylo and Siratro hays (average 279 g/kg total nitrogen) ($P<0.05$). The content of EE was similar for all the hays ($P>0.05$). However, Siratro and fine-stem stylo contained more ash, Ca and P than Silverleaf *Desmodium* ($P<0.05$). The leaf content of the 1994 hays suggests that, relative to the 1993 oven-dried samples, a lot of leaf was lost when making Siratro and Silverleaf *Desmodium* hays. Comparison of the CP levels of the 1993 and 1994 hay crops indicates that the quality of hay can be quite variable from year to year. As for the oven-dried samples, the stems and leaves of fine-stem stylo hay tended to contain the least levels of CP relative to those of Siratro and Silverleaf *Desmodium*.

Discussion

The differences observed in the phenological development of the legumes were complementary and consistent with those reported by Robinson and Clatworthy (1980). Phenological development influenced nutritive value because it is associated with changes in proportions and composition of plant fractions. In general, leaves are more nutritious than stems (Mero, 1997). In the present study, for example, the leaves contained approximately twice as much CP as the stems. The chemical composition of the legumes was comparable to that reported by Adjei and Fianu (1985), Skerman, Cameron and Riveros (1988), Norton and Poppi (1995) and Mero (1997). Relative to the veld grasses of the high rainfall areas of Zimbabwe (Elliott and Folkertsen, 1961), the legumes were rich sources of CP, Ca and P for ruminants (NRC, 1981; 1984; 1985).

The loss in quality upon hay-making can be attributed to leaf loss. While the high fibre content of the serially-harvested and oven-dried fine-stem stylo samples was attributable to its high stem: leaf ratio and to the greater woodiness of the stems; that of the Silverleaf *Desmodium* hay was attributable to greater loss of leaves. High levels of fibre are associated with low feed intake and digestibility (Milford, 1967; Van Soest, 1982). The adverse qualities of fine-stem stylo were its low CP, low P and high fibre levels, while those of Silverleaf *Desmodium* were its relatively high levels of fibre and ADIN in the hay, high content of ADL and low levels of Ca and P.

Conclusion

It is concluded that the three legumes showed distinct differences in phenological development which, in turn, influenced their seasonal nutritive value. Consequently, the nutritive quality of the legumes was complementary across the season. The legumes, especially Siratro, contained relatively high levels of CP, Ca and P that can provide substantial supplementation to poor-quality roughages. There was a general reduction in nutritive value when the legumes were field-cured into hay compared to samples that were harvested at the same time in April and oven-dried. Overall, Siratro was chemically the most nutritious legume, followed by Silverleaf *Desmodium* and fine-stem stylo, in that order.

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REFERENCES

ADJEI, M. B. AND FIANU, F. K. 1985 The effect of cutting interval on the yields and nutritive value of some tropical legumes on the coastal grassland of Ghana. *Tropical Grasslands* **19:** 164–171.

AOAC. 1975 Official methods of analysis. 12th edition. Association of Official Analytical Chemists, Washington, D. C.

BARNES, D. L. AND CLATWORTHY, J. N. 1976 Research in veld and pasture production in relation to the Tribal Trust Lands. *The Rhodesia Science News* **10:** 271–282.

CLATWORTHY, J. N. 1984 Effect of reinforcement of native grazing with Silverleaf *Desmodium* (*Desmodium uncinatum*) on dry season performance of beef steers in Zimbabwe. *Tropical Grasslands* **18:**198–205.

CLATWORTHY, J. N. AND HOLLAND, D. G. E. 1979 Effects of legume reinforcement of veld on the performance of beef steers. *Proceedings of the Grassland Society of Southern Africa* **14:** 111–114.

ELLIOTT, R. C. AND FOLKERTSEN, K. 1961 Seasonal changes in composition and yields of veld grass. *Rhodesia Agricultural Journal* **58:** 186–187.

GOERING, H. K. AND VAN SOEST, P. J. 1970 Forage fiber analyses (Apparatus, reagents, procedures, and some applications). Agriculture Handbook No. 379. Agricultural Research Service, United States Department of Agriculture, Washington, D. C.

MERO, R. N. 1997 Improved grasses and legumes as feed resources for Central Tanzania. Doctoral thesis. Swedish University of Agricultural Sciences, Uppsala.

MILFORD, R. 1967 Nutritive values and chemical composition of seven tropical legumes and lucerne grown in subtropical southeastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **7**: 540–545.

NORTON, B. W. AND POPPI, D. P. 1995 Composition and nutritional attributes of pasture legumes, p. 23–47. In: Tropical legumes in animal nutrition. D'Mello, J. P. F. and Devendra, C., CAB International, Wallingford, UK.

NRC. 1981 Nutrient requirements of goats. National Academy Press, Washington, D. C.

NRC. 1984 Nutrient requirements of beef cattle. 6^{th} rev. ed. National Academy Press, Washington, D. C.

NRC. 1985 Nutrient requirements of sheep. 6th rev.ed. National Academy Press, Washington, D. C.

ROBINSON, J. AND CLATWORTHY, J. 1980 Grasses and legumes for pastures. Natural Resources Board, Harare, Zimbabwe.